

Original Research Article

Preoperative hyponatremia as a predictor of complicated acute appendicitis: a prospective observational study

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ABSTRACT

Background: Acute appendicitis is the most frequent surgical emergency and a leading cause of acute abdominal pain, carrying a lifetime risk of approximately 6%. Clinical presentation is often misleading and hyponatremia has been proposed as a biochemical marker for complicated acute appendicitis. This study evaluated the role of serum sodium as a marker of appendicitis severity.

Methods: This hospital-based, observational prospective study was conducted in the department of general surgery, SMS Medical College, Jaipur, from August 2024 to September 2025, and enrolled 100 adult patients (>18 years) diagnosed with appendicitis. Patients were categorized into hyponatremic (serum sodium <135 mEq/l) and normonatremic groups. Data were collected on demographics, clinical presentation (Alvarado score), white blood cell count, surgical findings, and postoperative recovery. The primary objective was to evaluate serum sodium as a marker of appendicitis severity; secondary objectives were to assess its impact on surgical site infection rates and duration of hospital stay.

Results: Hyponatremic patients (mean age 36.76 ± 17.54 years) were significantly older and predominantly male compared with normonatremic patients. Gastrointestinal symptoms including nausea/vomiting (84% versus 32%) and anorexia (76% versus 48%), were more prevalent in the hyponatremic group, and 94% of hyponatremic patients required hospitalization for 3 days or longer, compared with 66% of normonatremic patients. Hyponatremia showed a strong association with complicated pathology, but its predictive value for surgical site infection was weak (16% versus 12%), and white blood cell counts lacked specificity for differentiating disease severity between groups.

Conclusions: Serum sodium appears to be a reliable, objective surrogate marker for predicting complicated appendicitis, reflecting systemic inflammation and increased hospital resource utilization, and may aid early identification of high-risk patients who require urgent intervention, particularly when Alvarado scores are equivocal.

Keywords: Acute appendicitis, Alvarado score, Complicated appendicitis, Hyponatremia, Surgical site infection

INTRODUCTION

Acute appendicitis is the most common surgical emergency worldwide and remains a leading cause of acute abdominal pain requiring emergency surgery.¹ Despite advances in diagnostic modalities and surgical management, complicated acute appendicitis, characterized by perforation, gangrene, abscess, or generalized peritonitis, continues to be associated with increased postoperative morbidity, prolonged hospital stay, and higher healthcare costs.²

Early diagnosis of appendicitis, particularly before progression to perforation, remains challenging because clinical presentation is often variable, especially in children and elderly patients. Although clinical scoring systems, laboratory inflammatory markers, and imaging techniques have improved diagnostic accuracy, differentiating uncomplicated from complicated appendicitis before surgery remains difficult, and delayed diagnosis increases the risk of perforation and adverse postoperative outcomes.³

Inflammatory biomarkers such as white blood cell count, C-reactive protein and neutrophil count are widely used in clinical practice; however, their ability to accurately predict disease severity is limited. Recently, serum sodium has emerged as a potential biomarker for complicated appendicitis. The proposed mechanism involves cytokine-mediated non-osmotic release of antidiuretic hormone during severe inflammation, resulting in dilutional hyponatremia. Several studies have reported an association between hyponatremia and complicated appendicitis, although evidence remains inconsistent across different populations.⁴

Identifying reliable, inexpensive, and readily available biomarkers for early prediction of complicated appendicitis is therefore clinically important to facilitate timely surgical intervention and improve patient outcomes. This study aimed to evaluate the role of hyponatremia in assessing the severity of appendicitis, with a primary objective of examining serum sodium as a biochemical marker of disease severity, and a secondary objective of evaluating its association with postoperative morbidity, specifically surgical site infection and duration of hospital stay.

METHODS

Study design and setting

This was a hospital-based, observational prospective study conducted in the Department of General Surgery at SMS Medical College and Attached Hospitals, Jaipur, Rajasthan, from August 2024 to September 2025.

Participants

The study enrolled 100 adult patients (>18 years of age) admitted with a diagnosis of appendicitis who provided informed consent to participate. Patients undergoing incidental or interval appendectomy, those with appendicular neoplasms, those in whom per-operative findings were other than appendicitis, and pregnant females were excluded. Patients were categorized into a hyponatremic group (serum sodium <135 mEq/l) and a normonatremic group (serum sodium ≥135 mEq/l) based on preoperative serum sodium levels.

Data collection

A pre-tested, pre-designed proforma was used to collect data. On admission, presenting complaints and detailed history were recorded, and clinical examination was performed, including assessment using the Alvarado score. Routine investigations included complete blood count, prothrombin time/international normalized ratio, blood sugar, serum electrolytes, liver function tests, renal function tests, HBsAg, anti-HCV, and HIV serology. Radiological imaging comprised chest radiography and whole-abdomen ultrasonography to identify an inflamed appendix or collection in the right iliac fossa or pelvis.

Patients meeting operative criteria underwent appendectomy, and intraoperative findings were recorded as uncomplicated (inflamed appendix) or complicated (gangrenous or perforated appendix, with or without localized or generalized peritoneal collection). Postoperative outcomes recorded included surgical site infection and duration of hospital stay.

Statistical analysis

Continuous variables are presented as mean±standard deviation and were compared using the independent-samples t-test. Categorical variables are presented as frequencies and percentages and were compared using the Chi-square test or Fisher's exact test, as appropriate, given expected cell counts. A two-sided p value <0.05 was considered statistically significant.

RESULTS

Of the 100 patients enrolled, 50 were hyponatremic (serum sodium <135 mEq/l) and 50 were normonatremic. Hyponatremic patients had a mean age of 36.76±17.54 years, compared with 32.34±13.26 years in the normonatremic group, and were predominantly male (68% versus 56%) (Table 1).

Table 1: Distribution of hyponatremia and normonatremia by age group and sex.

Variables	Hyponatremia (n=50) (%)	Normonatremia (n=50) (%)
Age (years)		
≤20	8 (16)	8 (16)
21-30	17 (34)	22 (44)
31-40	9 (18)	9 (18)
41-50	5 (10)	5 (10)
51-60	4 (8)	3 (6)
>60	7 (14)	3 (6)
Mean±SD	36.76±17.54	32.34±13.26
Gender		
Male	34 (68)	28 (56)
Female	16 (32)	22 (44)

Gastrointestinal symptoms were more prevalent among hyponatremic patients: nausea/vomiting was present in 84% versus 32%, and anorexia in 76% versus 48% of normonatremic patients. Fever, conversely, was more frequent in the normonatremic group (78% versus 56%) (Table 2).

Hospital stay of 3 days or longer was required in 94% of hyponatremic patients compared with 66% of normonatremic patients (Table 3).

Surgical site infection occurred in 16% of hyponatremic patients versus 12% of normonatremic patients, an overall incidence of 14% (Table 4).

High Alvarado scores (7-10 points) were recorded in 96% of normonatremic patients compared with 70% of hyponatremic patients, with the hyponatremic group

showing a higher proportion of equivocal scores (5-6 points, 28% versus 4%) (Table 5).

Table 2: Presenting complaints in hyponatremic and normonatremic patients.

Symptoms	Hyponatremia (n=50) (%)	Normonatremia (n=50) (%)
Fever- present	28 (56)	39 (78)
Anorexia- present	38 (76)	24 (48)
Nausea/vomiting- present	42 (84)	24 (32)

Table 3: Duration of hospital stay.

Hospital stays	Hyponatremia (n=50) (%)	Normonatremia (n=50) (%)	Total (n=100) (%)
<3 days	3 (6)	17 (34)	20 (20)
3–5 days	38 (76)	23 (46)	61 (61)
>5 days	9 (18)	10 (20)	19 (19)
Total	50 (100)	50 (100)	100 (100)

Table 4: Surgical site infection incidence.

SSI	Hyponatremia (n=50) (%)	Normonatremia (n=50) (%)	Total (n=100) (%)
Present	8 (16)	6 (12)	14 (14)
Absent	42 (84)	44 (88)	86 (86)
Total	50 (100)	50 (100)	100 (100)

Table 5: Alvarado score distribution.

Alvarado scores	Hyponatremia (n=50) (%)	Normonatremia (n=50) (%)	Total (n=100) (%)
Mild (1-4)	1 (2)	0 (0)	1 (1)
Moderate (5-6)	14 (28)	2 (4)	16 (16)
High (7-10)	35 (70)	48 (96)	83 (83)
Total	50 (100)	50 (100)	100 (100)

Table 6: Age distribution of uncomplicated and complicated appendicitis cases.

Age groups (years)	Hyponatremia (%)	Normonatremia (%)	P value
Uncomplicated cases			0.009
≤20	5 (55.56)	7 (77.78)	
21-30	0 (0)	16*	
31-40	2 (22.22)	5 (55.56)	
41-50	0 (0)	4*	
51-60	2 (22.22)	3 (33.33)	
>60	0 (0)	1*	
Complicated cases			0.025
≤20	3 (7.32)	1 (7.14)	
21-30	17 (41.46)	6 (42.86)	
31-40	7 (17.07)	4 (28.57)	
41-50	5 (12.20)	1 (7.14)	
51-60	2 (4.88)	0 (0)	
>60	7 (17.07)	2 (14.29)	

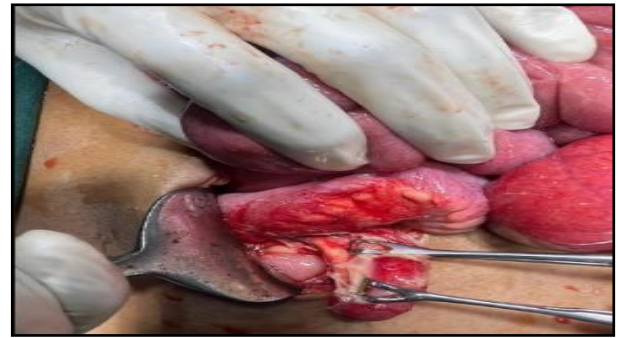
*Percentage as reported in the original data could not be verified against the row denominator and should be re-checked against source records before submission.

Table 7: White blood cell count distribution by complication status.

WBC counts	Hyponatremia (%)	Normonatremia (%)	P value
Uncomplicated cases			0.18
<11,000/mm ³	0 (0)	8 (22.22)	
>11,000/mm ³	9 (100)	28 (77.78)	
Complicated cases			1.00
<11,000/mm ³	3 (7.32)	1 (7.14)	
>11,000/mm ³	38 (92.68)	13 (92.86)	

A statistically significant association was observed between age distribution and complicated disease status in both the hyponatremic and normonatremic groups ($p=0.009$ for uncomplicated cases; $p=0.025$ for complicated cases). Among complicated cases, the 21-30-year age group accounted for the largest proportion in both groups (41.46% and 42.86%, respectively), while a secondary rise was observed in patients older than 60 years in the hyponatremic group (17.07% versus 14.29%) (Table 6).

Among uncomplicated cases, leukocytosis (WBC >11,000 cells/mm³) showed no significant difference between groups ($p=0.18$), and among complicated cases, leukocytosis was present in 92.68% of hyponatremic and 92.86% of normonatremic patients ($p=1.00$), indicating that WBC count did not differentiate disease severity between groups (Table 7).

**Figure 1: Inflamed appendix.****Figure 2: Appendicitis with gangrenous base.****Figure 3: Perforated appendix.**

DISCUSSION

This hospital-based observational prospective study, conducted in the department of general surgery at SMS Medical College and Attached Hospitals, Jaipur, between August 2024 and September 2025, enrolled 100 adult patients admitted with appendicitis to evaluate serum sodium, specifically hyponatremia (<135 mEq/l), as a marker of disease severity and risk stratification.

Appendicitis in this cohort peaked in young adults (21-30 years), while hyponatremic patients were significantly older than normonatremic patients (mean 36.76 versus 32.34 years, $p<0.01$), linking advancing age with electrolyte imbalance and greater disease complexity. This is consistent with Ustuner et al, who reported a significantly higher mean age in complicated compared with uncomplicated appendicitis (40 versus 28 years, $p<0.01$), and with Kaser et al, who identified hyponatremia specifically as a marker of infectious perforation in patients older than 50 years.^{5,6}

Male predominance was observed overall (62%), and was more marked in the hyponatremic group (68%) than the normonatremic group (56%), suggesting a possible association between male sex and hyponatremic, complicated presentations. Balaji et al similarly reported a high male prevalence (83.7%), while Symeonidis et al and Ustuner et al reported higher proportions of female patients, likely reflecting differing study populations.^{5,7,8} Taken together, these findings support an association between male sex and complicated, hyponatremic appendicitis (Table 1).

Hyponatremic patients showed significantly higher rates of gastrointestinal symptoms, including nausea/vomiting and anorexia, than normonatremic patients, whereas fever was more common in the normonatremic group. The co-occurrence of fever and hyponatremia has previously been reported as an indicator of infectious perforation by Kaser et al.⁶ These findings, together with those of Giannis et al, support the interpretation that hyponatremia reflects cytokine-mediated systemic inflammation rather than simple dehydration, and may serve as a diagnostic marker for complicated appendicitis (Table 2).⁹

Ninety-four percent of hyponatremic patients required hospitalization for 3 days or longer, compared with 66% of normonatremic patients. This association between preoperative hyponatremia and prolonged hospital stay is consistent with Ustuner et al and Symeonidis et al, who reported longer stays for complicated cases (3.9-5.2 days) than for uncomplicated cases (1.8-3.0 days), supporting the use of hyponatremia as a surrogate marker for complicated appendicitis in preoperative planning and resource allocation (Table 3).^{5,8}

The overall surgical site infection rate of 14% fell within the 3-20% global benchmark reported by Di Saverio et al.¹⁰ Hyponatremia showed only a weak association with surgical site infection (16% versus 12%), consistent with Singla et al, who reported that while low sodium is a robust marker of anatomical severity, such as gangrene or perforation, it is not a strong independent predictor of localized wound infection (Table 4).¹¹

Although the Alvarado score is useful for initial diagnosis, it frequently yields equivocal results in complicated disease. High scores (7-10 points) were recorded in 96% of normonatremic patients compared with 70% of hyponatremic patients, with 28% of hyponatremic patients having equivocal scores. As Singla et al reported a mean sodium of 132.4 mEq/l in association with severe pathology, these findings suggest that clinicians should consider further imaging or urgent intervention when Alvarado scores are equivocal, to help identify gangrene or perforation (Table 5).¹¹

A statistically significant association was found between age distribution and complicated appendicitis ($p=0.025$). The 21-30-year age group accounted for over 41% of complicated cases, consistent with the 42.86% reported by Ustuner et al, while a secondary rise among patients older than 60 years was more pronounced in the hyponatremic group (17.07% versus 14.29%).⁵ This pattern is consistent with findings by Kaser et al and Symeonidis et al, which identify advanced age as a risk factor for perforation and hyponatremia as a specific indicator of infectious perforation in patients older than 50 years (Table 6).^{6,8}

While white blood cell elevation is a standard inflammatory marker in appendicitis, it lacked specificity for distinguishing uncomplicated from complicated disease in this cohort. Leukocytosis ($>11,000$ cells/mm³)

was present in the large majority of complicated cases, with no significant difference between hyponatremic and normonatremic groups ($p=1.00$). This is consistent with Singla et al, who reported that serum sodium provides greater prognostic specificity than white blood cell count for identifying patients at high risk of complications such as perforation (Table 7).¹¹

CONCLUSION

This study found a strong correlation between hyponatremia and specific demographic and recovery variables, with older patients significantly more likely to present with complicated appendicitis accompanied by electrolyte disturbance. Although the peak incidence of appendicitis remains among young adults, the association between low serum sodium and increased disease complexity becomes more pronounced with advancing age. Preoperative hyponatremia appears to be a clinically useful diagnostic and prognostic marker for identifying complicated appendicitis, such as gangrenous and perforated disease, likely reflecting severe systemic inflammation in which pro-inflammatory cytokines such as interleukin-6 trigger non-osmotic release of vasopressin and consequent dilutional hyponatremia. Hyponatremia may be particularly valuable in patients with equivocal Alvarado scores, where it can serve as an additional biochemical indicator of a higher likelihood of severe anatomical pathology.

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REFERENCES

1. Guller U, Hervey S, Purves H, Muhlbaier LH, Peterson ED, Eubanks S, et al. Laparoscopic versus open appendectomy: outcomes comparison based on a large administrative database. *Ann Surg.* 2004;239(1):43.
2. Debnath J, Kumar R, Mathur A, Sharma P, Kumar N, Shridhar N, et al. On the role of ultrasonography and CT scan in the diagnosis of acute appendicitis. *Indian J Surg.* 2015;77(3):221-6.
3. Lounis Y, Hugo J, Demarche M, Seghaye MC. Influence of age on clinical presentation, diagnosis delay and outcome in pre-school children with acute appendicitis. *BMC Pediatr.* 2020;20(1):151.
4. Humes DJ, Simpson J. Acute appendicitis. *BMJ.* 2006;333(7567):530-4.

5. Ustuner MA, Deniz A. A new predictive factor for complicated appendicitis: hyponatremia. *Eur J Med Investig.* 2020;4(3):401-4.
6. Käser SA, Furler R, Evequoz DC, Maurer CA. Hyponatremia is a specific marker of perforation in sigmoid diverticulitis or appendicitis in patients older than 50 years. *Gastroenterol Res Pract.* 2013;2013(1):462891.
7. Balaji K, Keerthinmayee K, Babu PS. Hyponatremia as a biochemical marker for complicated appendicitis: a prospective observational study. *Int J Med Pharm Res.* 2026;7(1):1024-9.
8. Symeonidis NG, Pavlidis ET, Psarras KK, Stavratsi K, Nikolaidou C, Marneri A, et al. Preoperative hyponatremia indicates complicated acute appendicitis. *Surg Res Pract.* 2022;2022:1-5.
9. Giannis D, Matenoglou E, Moris D. Hyponatremia as a marker of complicated appendicitis: a systematic review. *Surgeon.* 2020;18(5):295-304.
10. Di Saverio S, Podda M, De Simone B, Ceresoli M, Augustin G, Gori A, et al. Diagnosis and treatment of acute appendicitis: 2020 update of the WSES Jerusalem guidelines. *World J Emerg Surg.* 2020;15(1):27.
11. Singla S, Chanderbhan MP, Kesharwani S, Garg R, Pandey SB. Role of hyponatremia as a predictive biomarker for complicated acute appendicitis: a comparative clinical study. *Eur J Cardiovasc Med.* 2025;15(12):12-5.

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